APPENDIX (A – D)

In search for the missing arc root of the Southern California Batholith: P-T-t evolution of upper mantle xenoliths of the Colorado Plateau Transition Zone

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APPENDIX A

A1. ANALYTICAL METHOD

Petrogenetic Modeling: The Gibbs free energy minimization software package THERIAK-DOMINO (de Capitani & Petrakakis, 2010) and the thermodynamic end-member and solution models of the accompanying "tcdb55-p07" database (NCKFMAS(H)TO compositional system) were used to construct sample-specific P-T pseudosections. The effective bulk composition for input in domino was computed using mineral compositions with calculated modes for garnet, clinopyroxene, rutile, and the assumption that all amphibole represents former clinopyroxene, as suggested by textural observations (Fig. 3). Mineral modes and chemistry were combined and converted to weight percent whole rock bulk compositions using Rock Maker software (Buttner, 2012). The NCKFMAS(H)TO compositional system employed using the following activity-composition relationship (a-x) models: garnet, biotite and melt (White et al. 2007), orthopyroxene and spinel group (White et al. 2002), amphibole (Diener et al. 2007), clinopyroxene (Green et al. 2007), K-feldspar and plagioclase (Holland & Powell 2003), ilmenite (White et al. 2000) and cordierite (Holland & Powell 1998).

Garnet Sm-Nd Geo-/thermochronology: Neodymium isotopic ratios and complementary concentrations of Sm and Nd were measured by thermal ionization mass spectrometry (University of Arizona) on whole-rock powders. Garnet separates were analysed in an identical manner, except Nd was measured as an oxide using a separate procedure (Ducea et al., 2003). Garnet grains were separated from 10 samples using standard crushing, magnetic and density techniques and were purified by hand picking. Garnet grains free of visible inclusions and kelyphitic rims were powdered with an agate mortar and pestle. Powdered garnet fractions were then placed in 2M nitric acid in an effort to selectively leach micro inclusions. Powders were dissolved in large Savillex vials using a mixture of hot concentrated HF-HNO3 and later with cold concentrated HF-HClO4. The dissolved samples were mixed with the Caltech ^{147}Sm-^{150}Nd spike (Wasserburg *et al.*, 1981) after dissolution. The bulk of the REEs were separated in cation columns containing AG50W-X4 resin, using 4N HCl. Separation of Sm and Nd was achieved in anion columns containing LN Spec resin, using 0.1N to 0.75N HCl. The estimated analytical $\pm 2\sigma$ uncertainties for whole-rock and garnet powders analysed in this study are: $^{147}Sm/^{144}Nd = 0.1\%$, and $^{143}Nd/^{144}Nd = 0.0007\%$.

Zr-in-rutile Thermometry (Watson et al., 2006): Zirconium content of rutile increases with increasing temperature and is therefore applicable as a geothermometer (e.g., Watson et al., 2006). Data from 20 rutile grains (~3 analyses per grain) was acquired on a JEOL JXA-8900R electron microprobe at University of Minnesota.

Ti-in-ziccon Thermometry (Watson et al., 2006): Zircon trace element data was determined via single collector, magnetic sector ICP-MS, coupled with a 213 nm laser ablation system at Rice University. Unknown analyses were bracketed with BHV02, BCR, and NIST612 glass standards, all using a 30 µm spot size.

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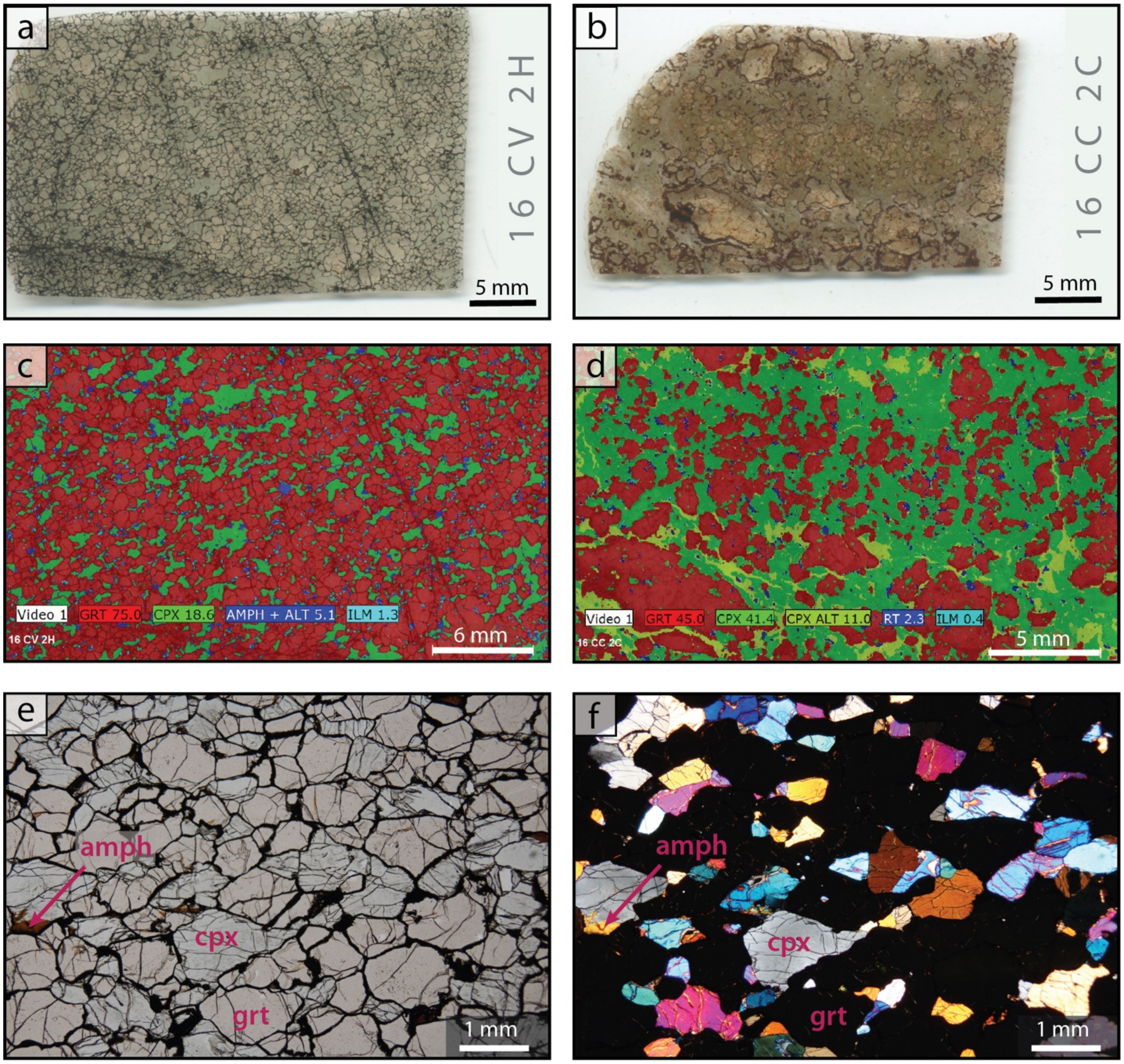
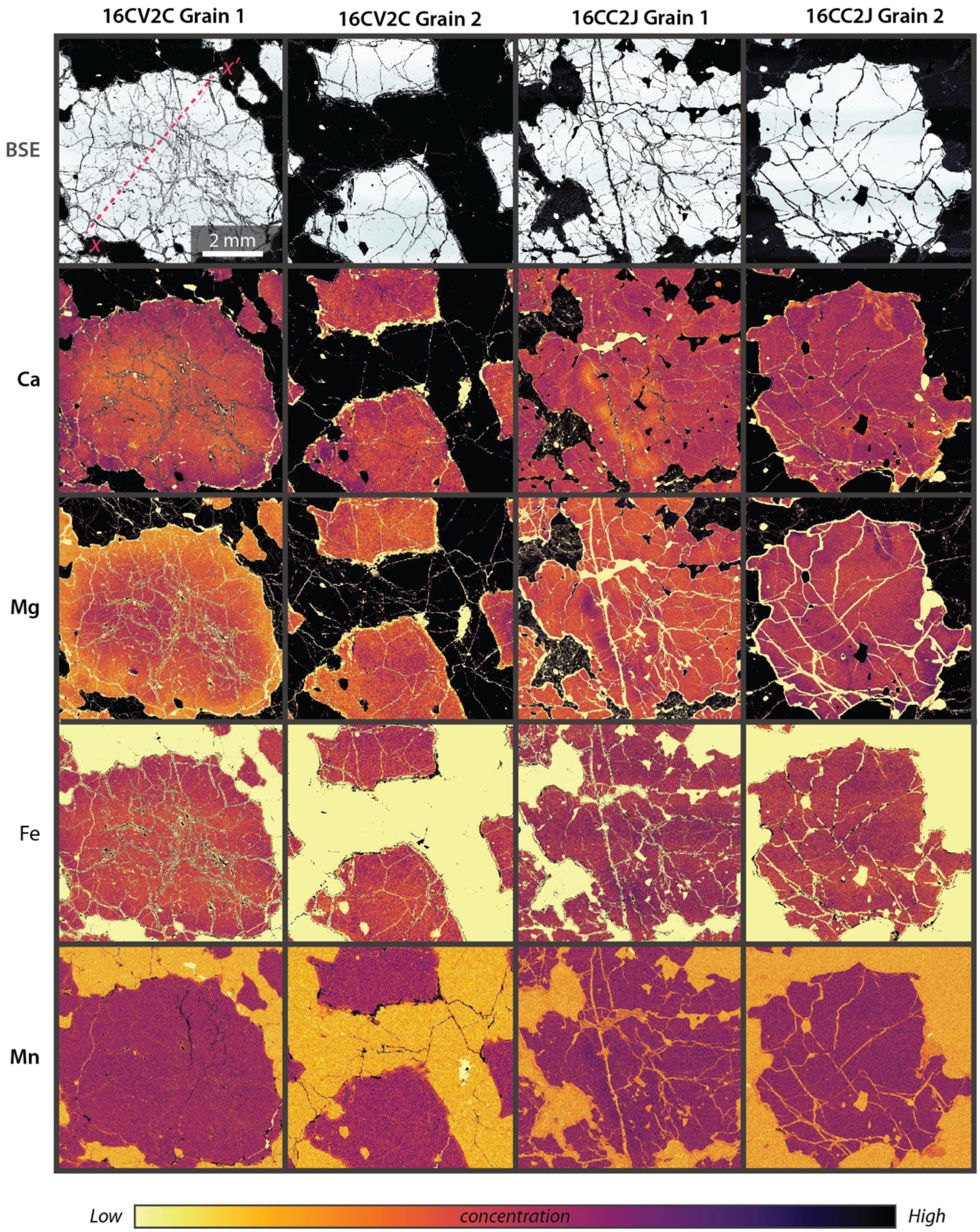
APPENDIX B



Appendix B. Arclogite mineral assemblage. *(a-b)* Thin section scans of fresh garnet pyroxenite from Chino Valley (a) and lava intruded and altered garnet pyroxenite from Camp Creek (b). The dull green minerals are clinopyroxene, the pale pink/brown minerals are garnet. Most of the opaque regions and garnet rims (b) represent kelyphitic garnet breakdown products. *(c-d)* Modal abundance maps made on µ-XRF for the samples shown in (a) and (b) respectively. The relative abundance of different phases shown in the labels in each map (e.g. (c) contains ~75% GRT (garnet)). *(e-f)* Sample 16CV2C – fresh clinopyroxenite from Chino Valley under plane polarized (e) and cross-polarized (f) light. Abbreviations (c-f) as follows: grt, garnet; cpx, clinopyroxene; amph, amphibole; alt, alterations; ilm, ilmenite; rt, rutile.

APPENDIX C



Appendix C. X-ray maps of arclogite garnets. First row shows the BSE (back scatter electron) images of the analyzed garnet (light) surrounded by clinopyroxene (black). X-X' line sections across BSE images of 16CV2C Grain1 is the locations of zonation profiles shown in Figure 4. Light colors represent relatively low concentration with light yellow for the lowest.

APPENDIX D

Table D1.
Whole rock composition for Camp Creek (CC) and Chino Valley (CV) samples.

Samples	16CC2C	16CC2I	16CC2J	16CC2U	16CC2X	16CV2C	16CV2FF	16CV2.5F	16CV2H	16CV2K
SiO2	43.13	44.66	41.74	43.14	41.96	42.08	41.53	42.01	40.60	40.04
Al2O3	14.97	14.99	18.02	15.26	16.69	16.71	18.51	17.58	18.41	19.21
TiO2	2.56	2.21	2.78	1.78	2.54	2.74	1.85	1.91	2.47	2.80
FeO	14.80	10.68	14.76	13.26	14.44	14.63	14.51	17.39	16.89	16.38
MgO	9.32	9.89	8.63	9.27	9.20	9.93	11.73	9.16	8.42	8.19
MnO	0.22	0.26	0.24	0.20	0.24	0.24	0.35	0.52	0.33	0.31
CaO	13.61	14.47	12.84	14.74	14.29	13.03	11.26	10.54	12.22	12.47
Na2O	1.38	1.98	0.98	1.43	0.66	0.63	0.25	0.90	0.66	0.61
P2O5	-	0.87	-	0.91	-	-	-	-	-	-

* Major elements in wt. % and all Fe as FeO

Table D2.
Summary of petrographic observations for Camp Creek (CC) and Chino Valley (CV) samples.

Samples	Petrography	Other features
16CC2C	Grt (kel) + cpx (alt) + ru + lava (amph, plag, bt, kfs, ep)	coarse, grt grains upto ~7.5mm
16CC2I	Grt + cpx (alt to amph) + ru + ilm + ap + amph	-
16CC2J	Grt (kel) + cpx (alt to amph, plag) + ru + ap	fresh
16CC2U	Grt (kel) + cpx (alt to amph) + ru + ap	coarse, almost all cpx altered
16CC2X	Grt (kel) + cpx (alt to amph, plag, phl) + ru + ilm	-
16CV2C	Grt + cpx (alt to amph) + ru + ilm	fresh
16CV2FF	Grt + cpx (alt to amph) + ru + ilm	amph preserves cpx ~90° cleavage
16CV2.5F	Grt (kel) + cpx (alt to amph, plag (An# 80), phl) + ru + ilm	-
16CV2H	Grt + cpx (alt to amph) + ru + ilm + ap + zr	fresh, extensive ru-ilm exsolution
16CV2K	Grt + cpx (alt to amph) + ru + ilm + ap	fresh

grt, garnet; kel, kelyphized; cpx clinopyroxene; alt, alterated; amph, amphibole; ru, rutile; bt, biotite; ilm, ilmenite; ap, apatite; zr, zircon; plag, plagioclase; an, anorthite; kfs, k-feldspar; ep, epidote; phl, phlogopite.